Examining common assumptions about recruitment using the RAM Legacy Stock Assessment Database

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Is fish recruitment related to spawner abundance?

YES

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Abstract.—We analyzed 364 spawner-recruitment time series to determine whether recruitment is related to spawner abundance. We pose three questions: 1) Does the highest recruitment occur when spawner abundance is high? 2) Does the lowest recruitment occur when spawner abundance is low? and 3) Is the mean recruitment higher if spawner abundance is above rather than below the median? We found that when there is a sufficient range in spawner abundance the answer to all three questions is almost always "yes." Thus, spawner abundance cannot be ignored in the management of fish populations. Recruitment overfishing appears to be a common problem.

Towards a new recruitment paradigm for fish stocks

NO

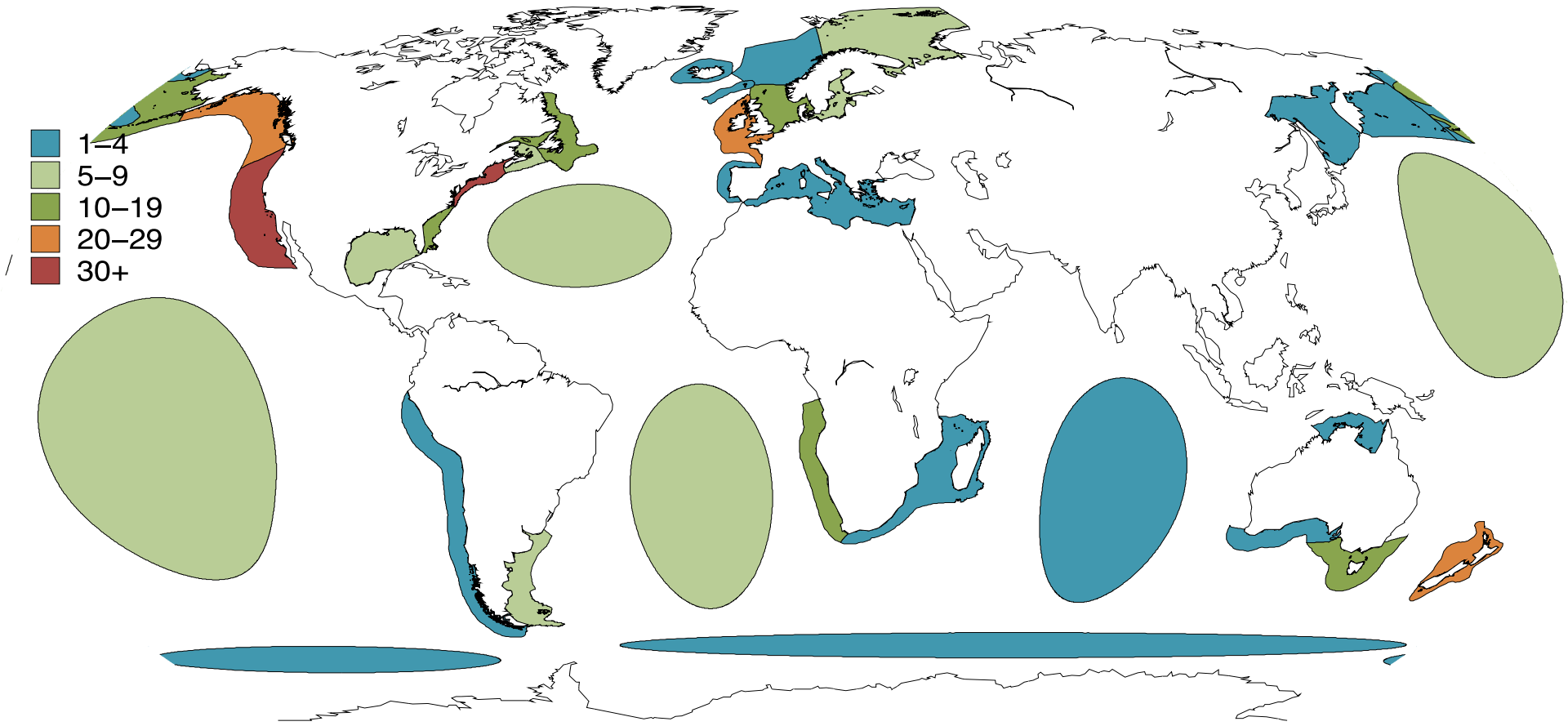
D.J. Gilbert

Abstract: The stock recruitment paradigm involves the hypothesis that recruitment (R) to a fish stock is positively related to the spawning stock biomass (SSB) of the stock, at low SSB. I propose a "recruitment states" hypothesis wherein R is independent of SSB but has different mean values during successive periods. Meta-analysis was used to test the null hypothesis that recruitment is a series of random, independent events, against these two alternative hypotheses, for 153 marine spawning bony fish stocks and 31 salmonid stocks. A test statistic for the stock recruitment paradigm, based on estimating derivatives from the first differences of the time series, was not significant for the marine stocks. The null hypothesis was rejected for the salmonid stocks. Recruitment states models significantly fitted time series for the marine stocks. Ricker models also significantly fitted these data, conflicting with the derivatives test result. However, because SSB is dependent on R, lagged by the age at maturity, a period in a low recruitment state would tend to lead to a period of low SSB. Therefore, the significance of the fit to the Ricker model may have been spurious. The recruitment states model best explained the meta-dataset for the marine stocks.

- Is recruitment related to spawning biomass?
- Do recruitment dynamics change over time?
- Are changes in recruitment dynamics synchronous within an LME?

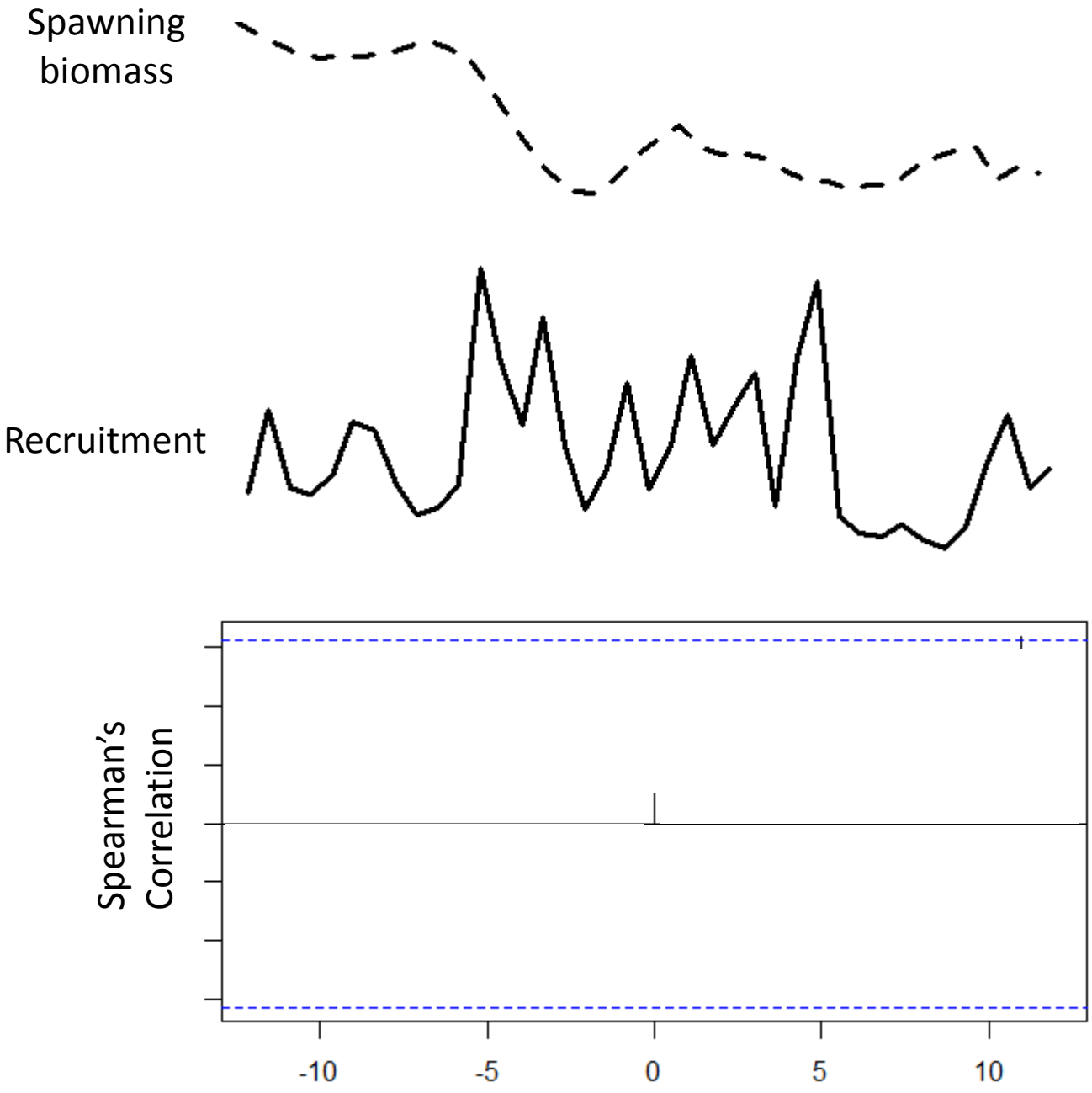
RAM legacy stock assessment database:

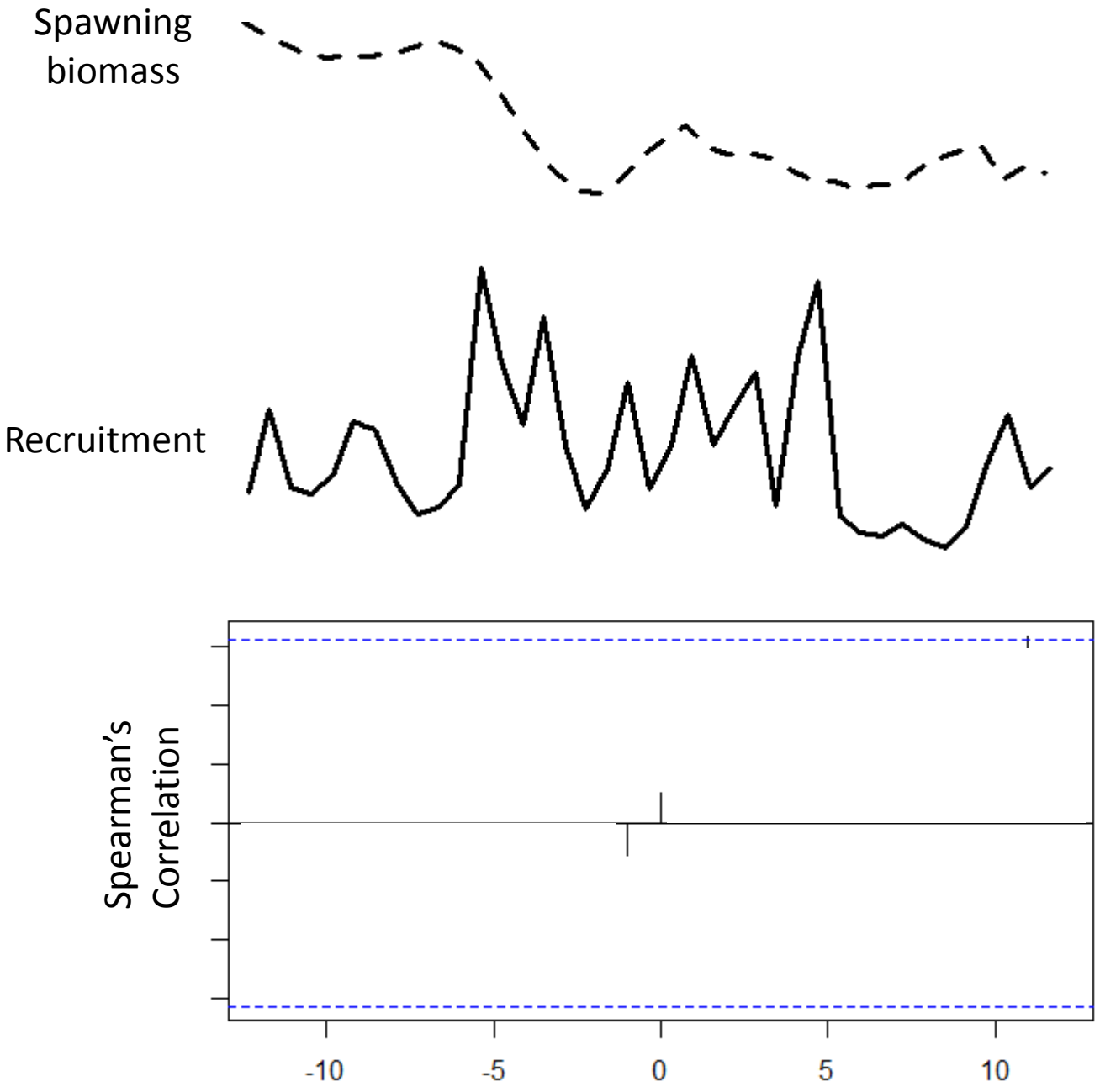
- >= 20 estimates of recruitment and SSB
- No estimates directly from a s/r curve (the tails of the time series were often removed)
- 224 stocks



Although not 'data', these estimates are:

1) used to provide management advice
2) incorporate many data sources and represent the best available science


Spawning biomass
Recruitment
Spearman's Correlation
-10
-5
0
5
10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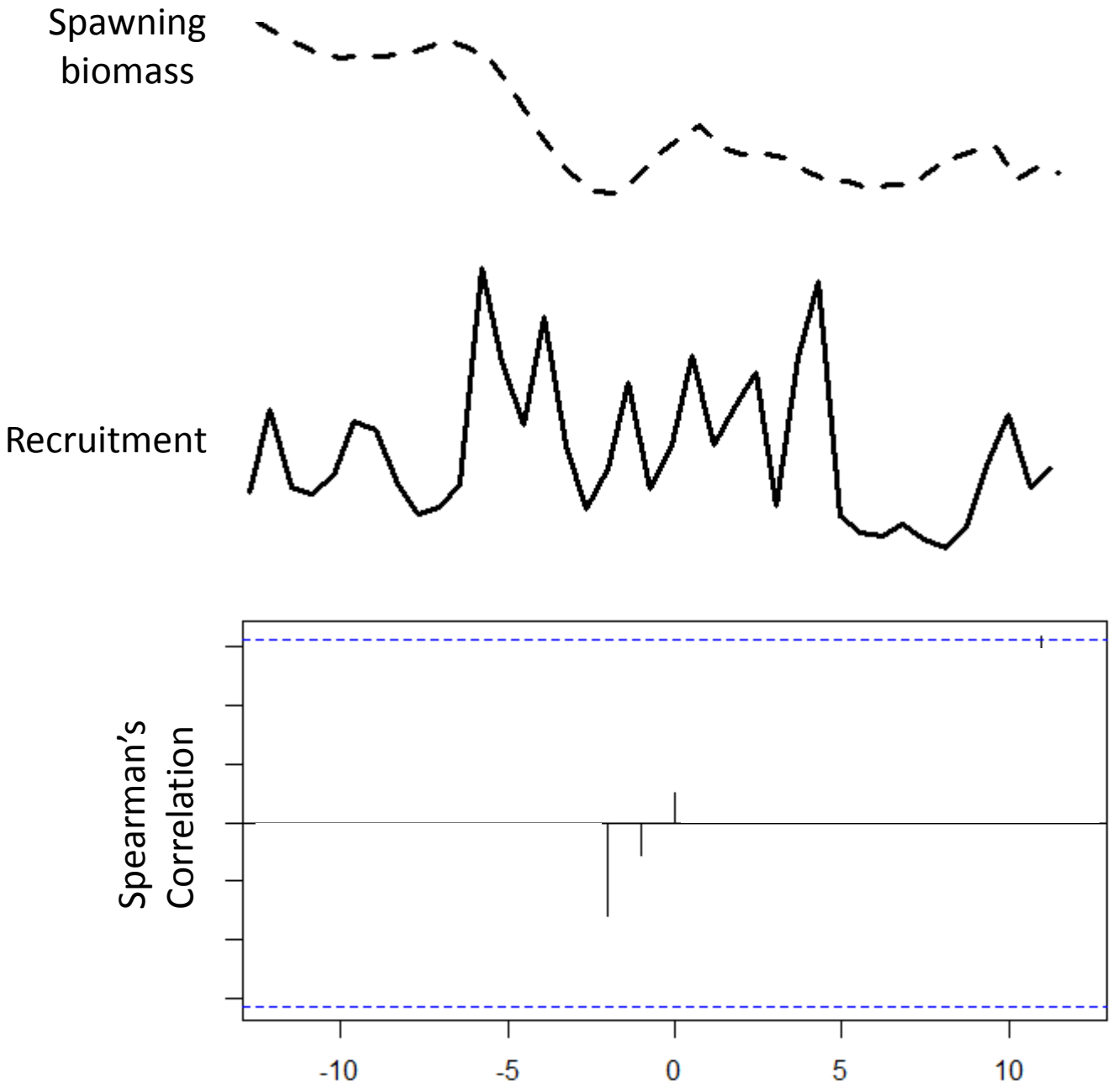
-10
-5
0
5
10


Spawning biomass
Recruitment
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-10
-5
0
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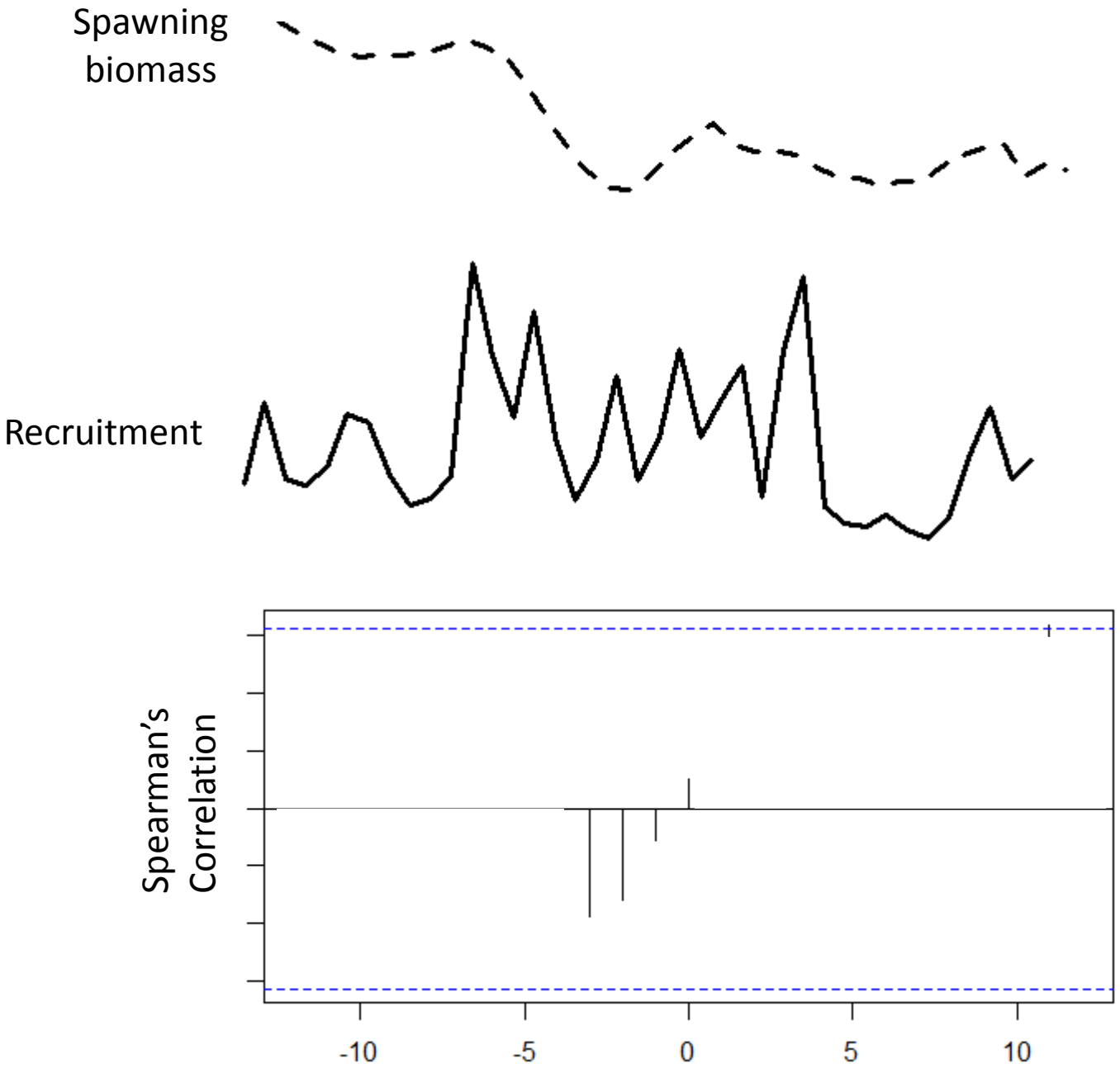
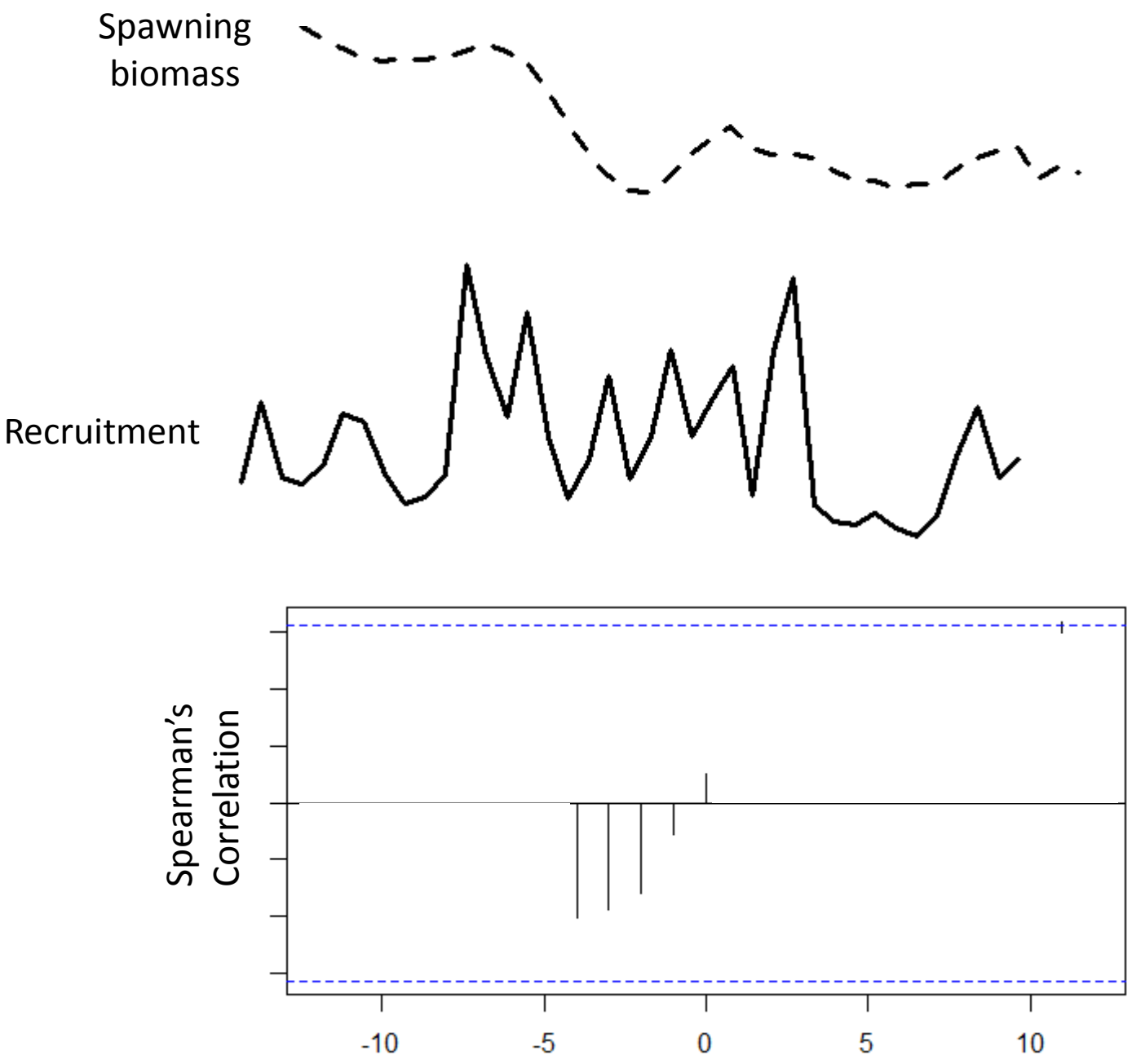
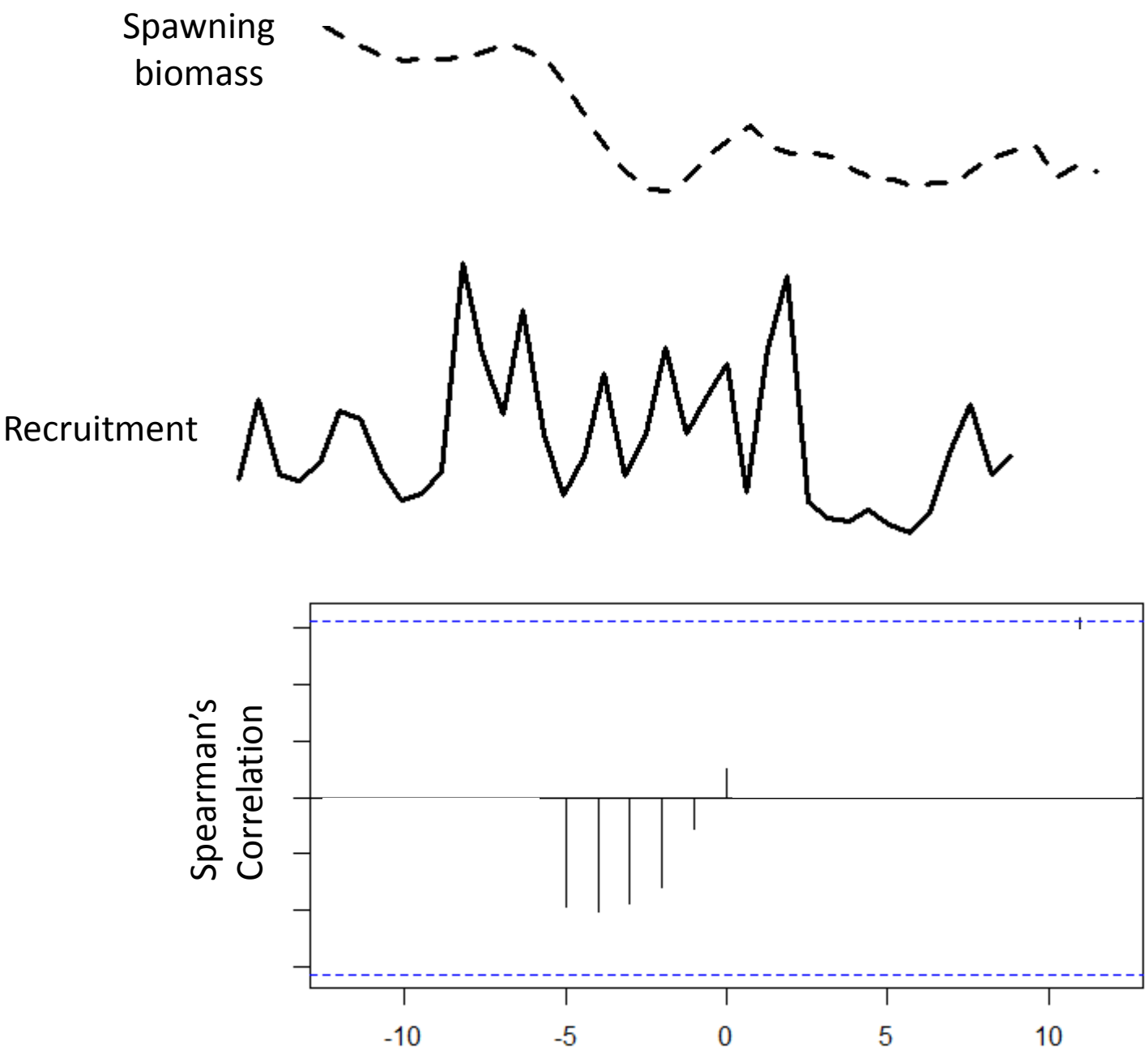
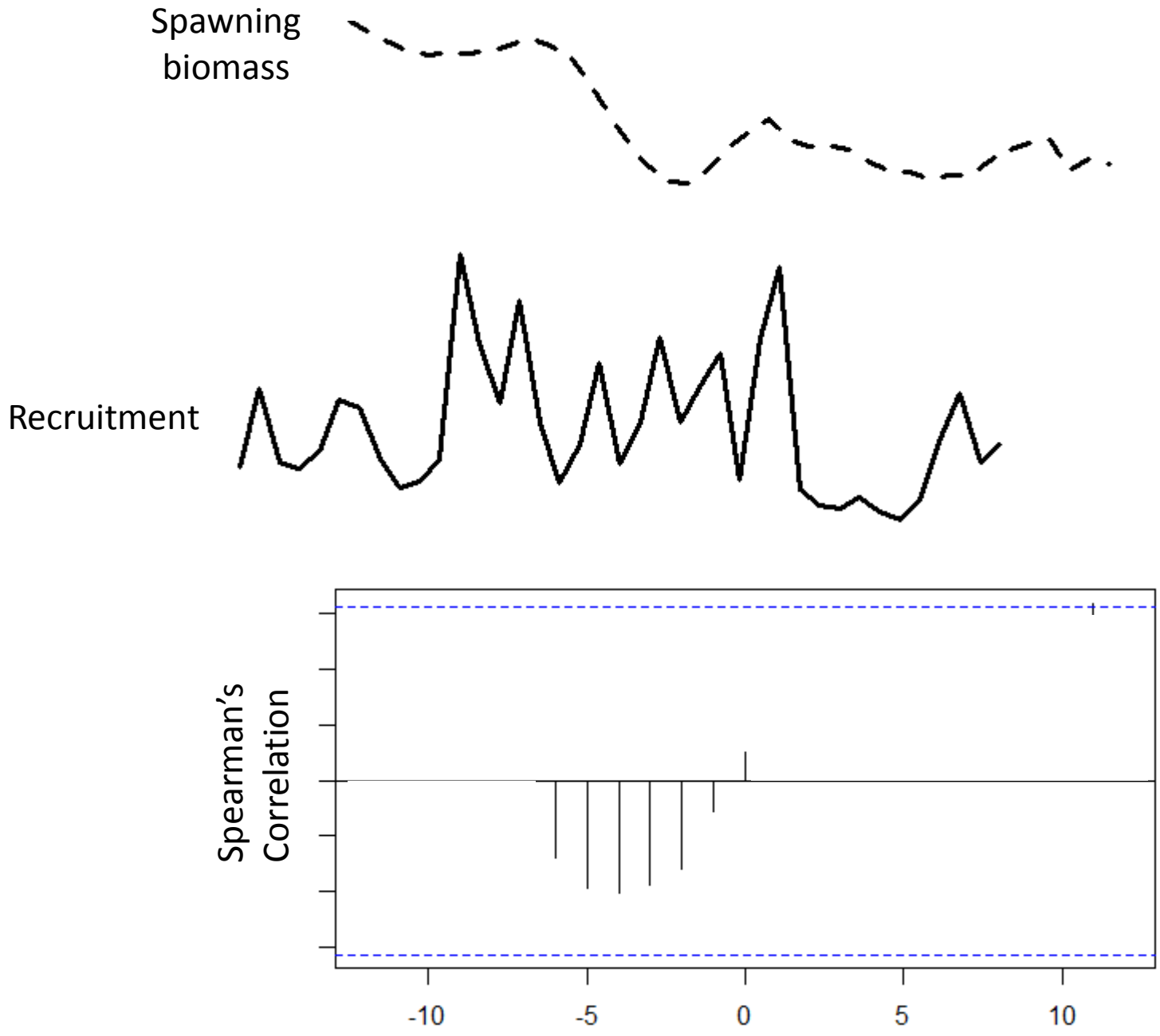
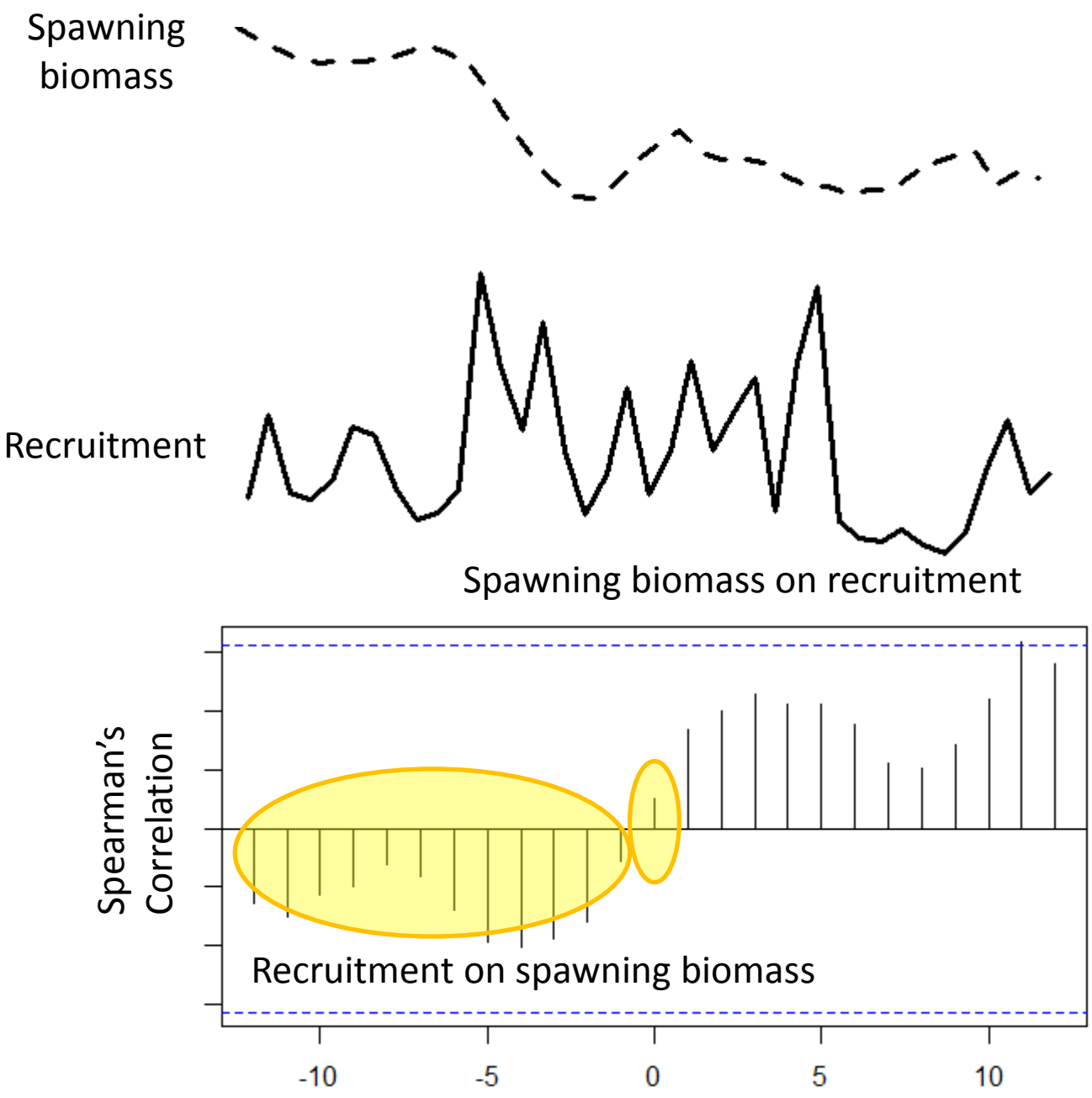
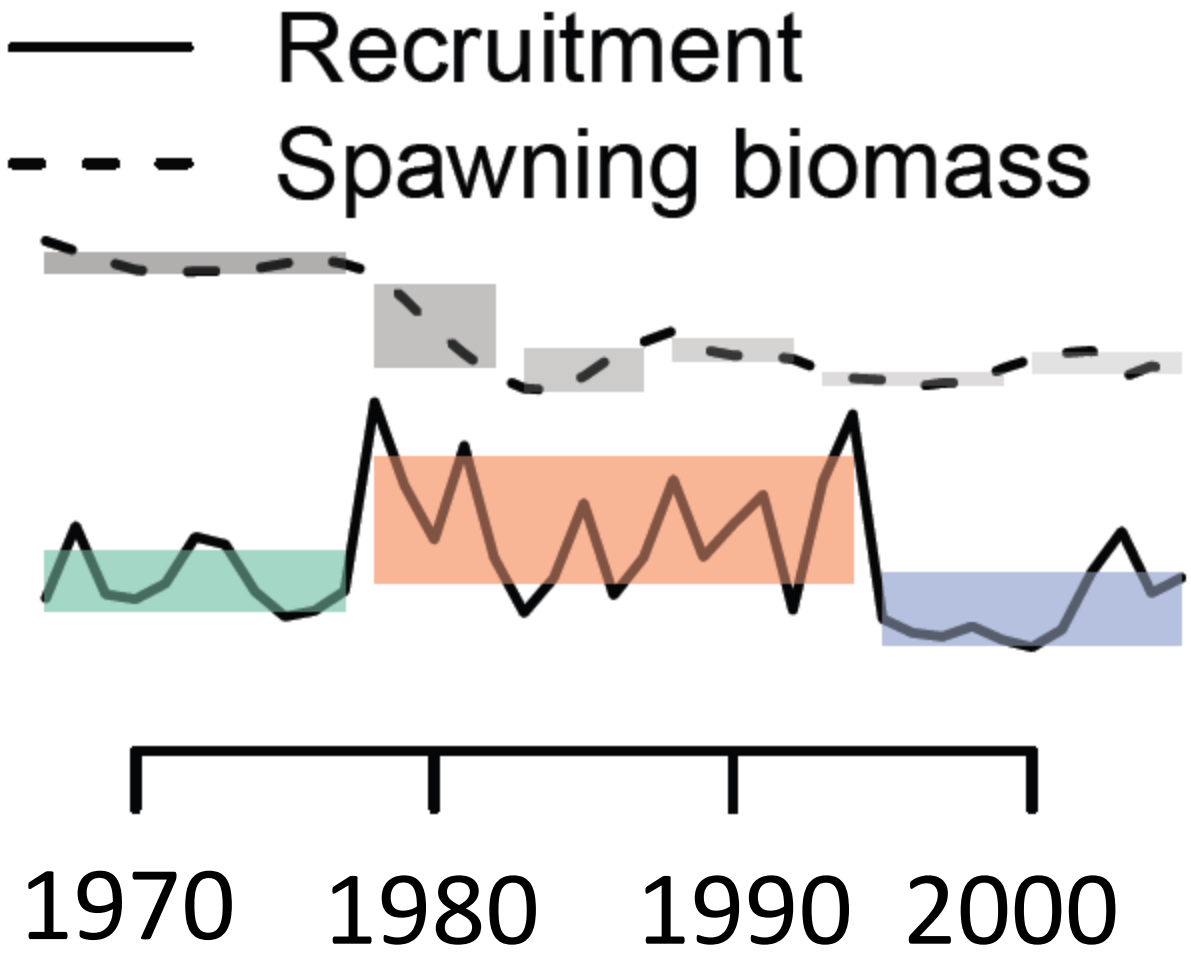

Spawning biomass
Recruitment
Spearman's Correlation
-10
-5
0
5
10


Spawning biomass
Recruitment
Spearman's Correlation
-10
-5
0
5
10

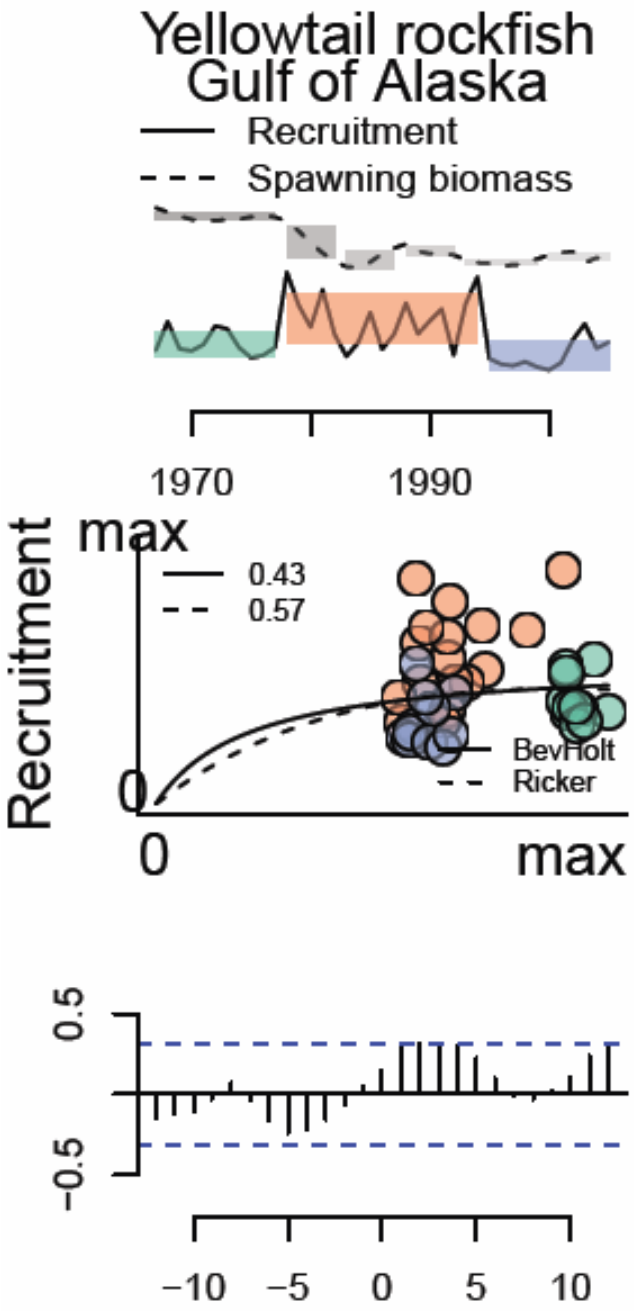

Spawning biomass
Recruitment
Spearman's Correlation
-10
-5
0
5
10


Spawning biomass
Recruitment
Spearman's Correlation
-10
-5
0
5
10


Spawning biomass
Recruitment
Spawning biomass on recruitment
Spearman's Correlation
Recruitment on spawning biomass
-10
-5
0
5
10



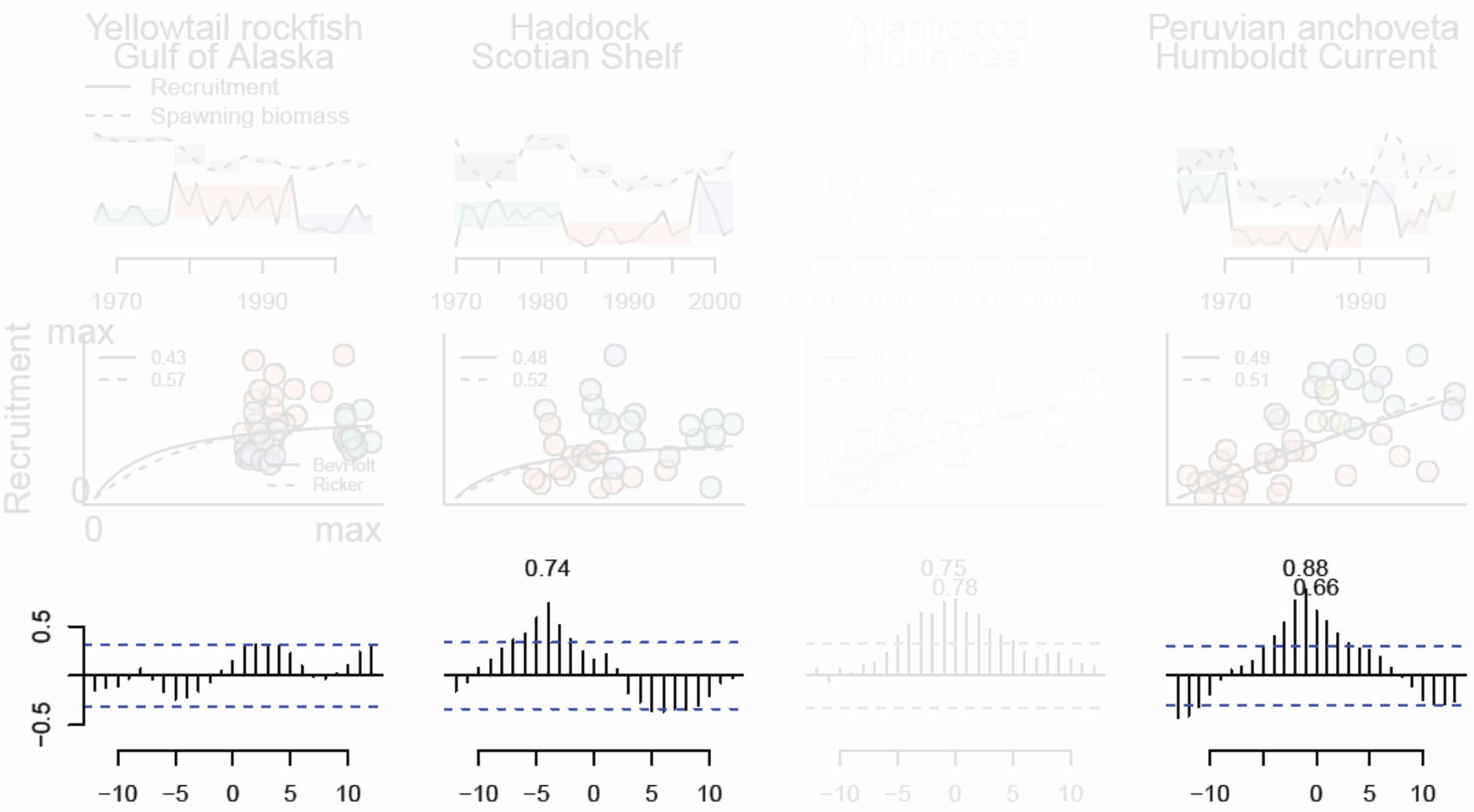
‘Sequential t-test for regime shifts’; Rodionov, 2004.


Yellowtail rockfish
Gulf of Alaska
Recruitment
Spawning biomass
1970
1990
Recruitment
max
0.43
0.57
BevHolt
Ricker
0
0
max
0.5
−0.5
−10
−5
0
5
10

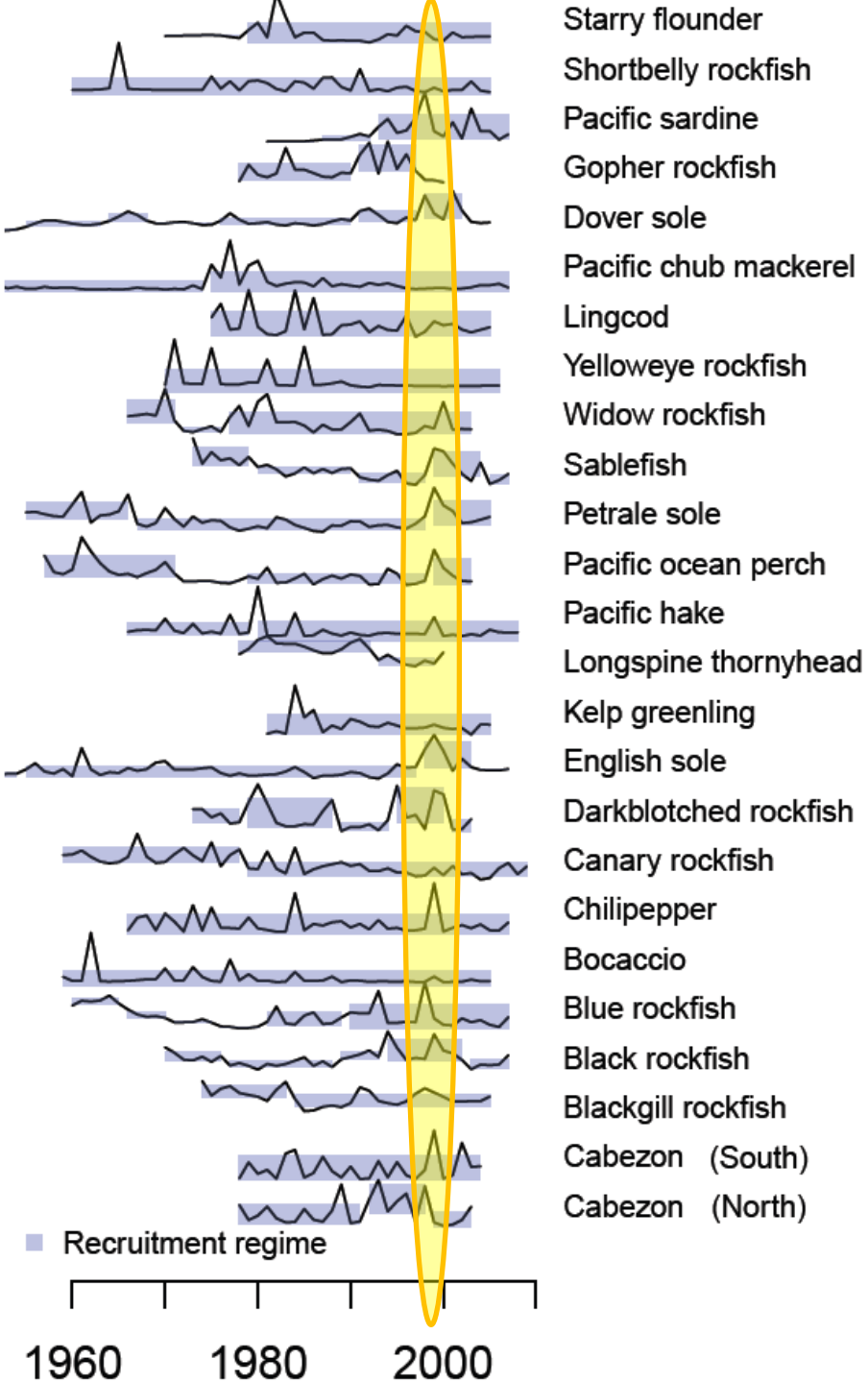
Environmentally driven

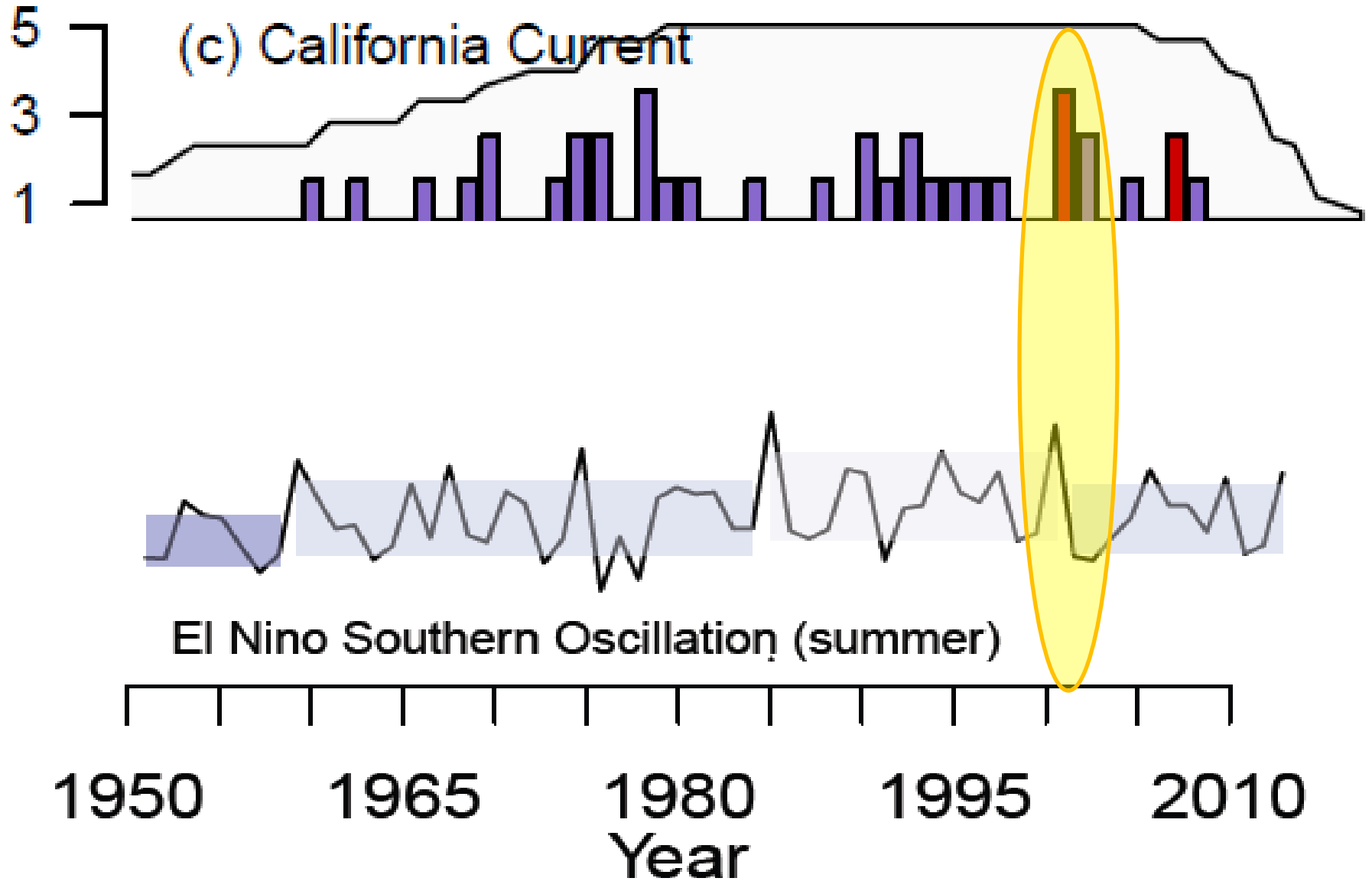
Spawning biomass driven

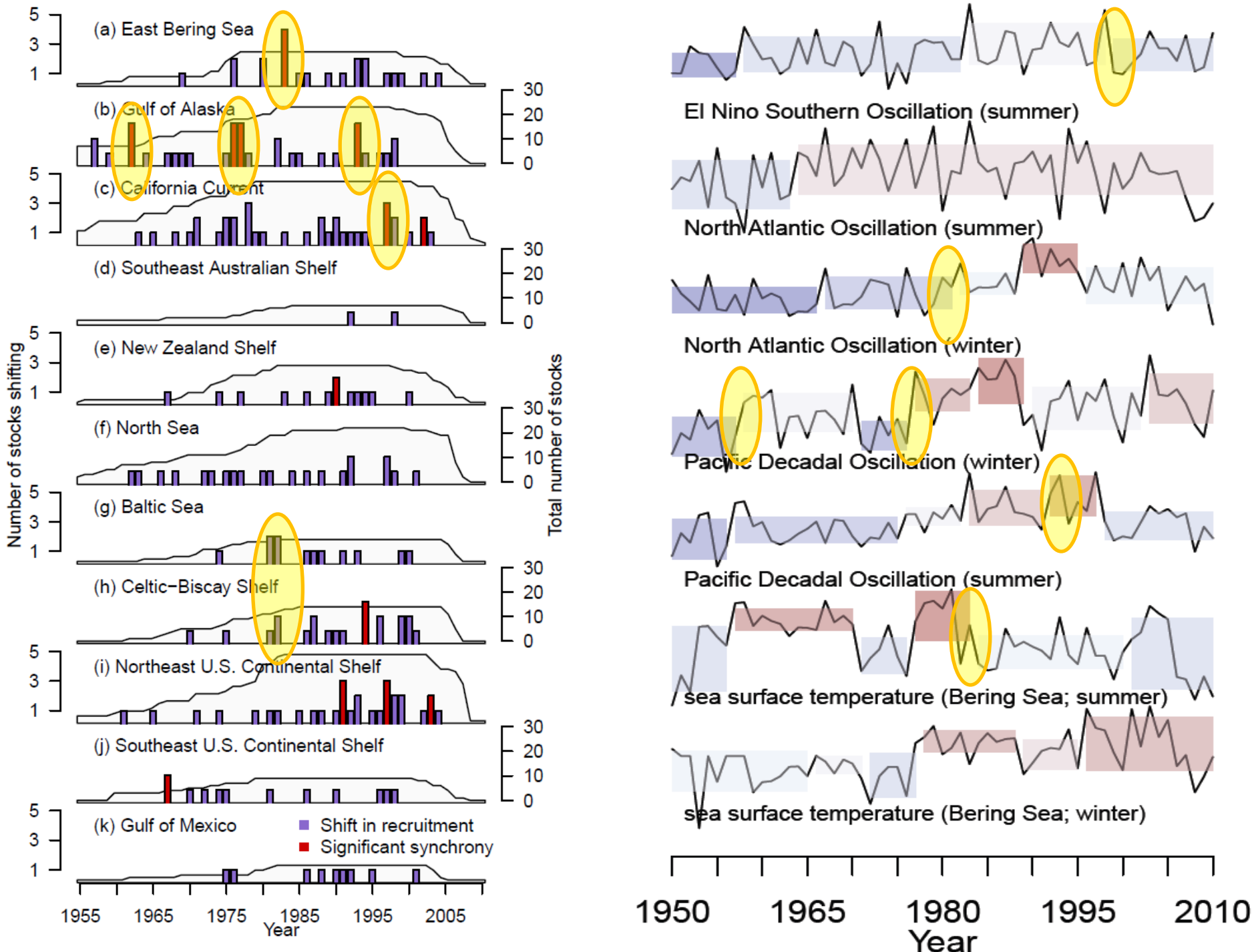
Environmentally-influenced



77% of stocks with recruitment not related to spawning biomass show changes in average recruitment over time


Starry flounder
Shortbelly rockfish
Pacific sardine
Gopher rockfish
Dover sole
Pacific chub mackerel
Lingcod
Yelloweye rockfish
Widow rockfish
Sablefish
Petrale sole
Pacific ocean perch
Pacific hake
Longspine thornyhead
Kelp greenling
English sole
Darkblotched rockfish
Canary rockfish
Chilipepper
Bocaccio
Blue rockfish
Black rockfish
Blackgill rockfish
Cabezon (South)
Cabezon (North)
Recruitment regime
1960
1980
2000

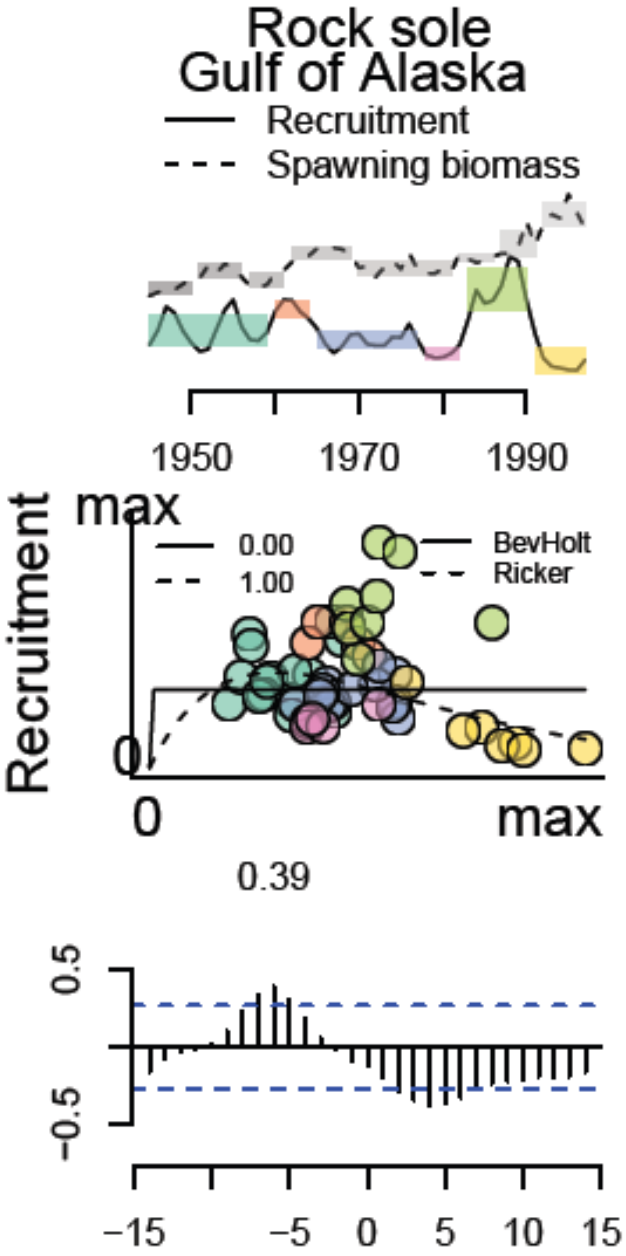

5
3
1
(c) California Current
El Nino Southern Oscillation (summer)
1950
1965
1980
1995
2010
Year

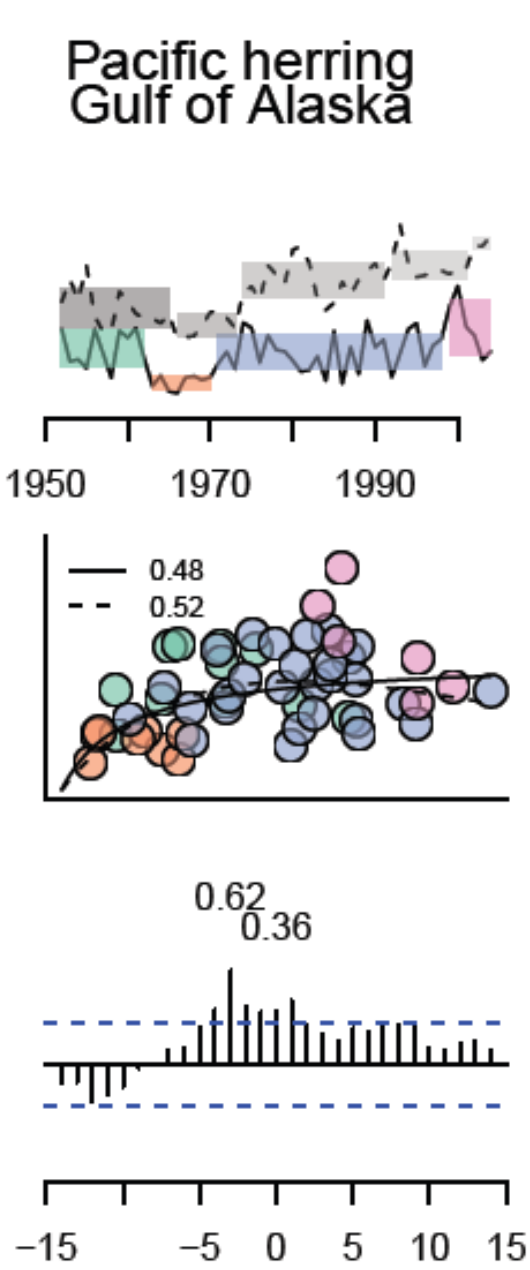

(a) East Bering Sea
(b) Gulf of Alaska
(c) California Current
(d) Southeast Australian Shelf
(e) New Zealand Shelf
(f) North Sea
(g) Baltic Sea
(h) Celtic−Biscay Shelf
(i) Northeast U.S. Continental Shelf
(j) Southeast U.S. Continental Shelf
(k) Gulf of Mexico
Shift in recruitment
Significant synchrony
Number of stocks shifting
Total number of stocks
Year
1955
1965
1975
1985
1995
2005
El Nino Southern Oscillation (summer)
North Atlantic Oscillation (summer)
North Atlantic Oscillation (winter)
Pacific Decadal Oscillation (winter)
Pacific Decadal Oscillation (summer)
sea surface temperature (Bering Sea; summer)
sea surface temperature (Bering Sea; winter)
1950
1965
1980
1995
2010
Year

BREAKING NEWS: RECRUITMENT VARIES!
(but differently than we often assume)

- Recruitment for 62% of stocks doesn't increase as spawning biomass does.
- Only 14% of stocks appear to have a strong stock recruit relationship.
- Recruitment dynamics change for 77% of environmentally-influenced/driven stocks.
- These changes often occur synchronously within LMEs.

Be careful with inference from stock recruit models when recruitment is 'regime-like'?



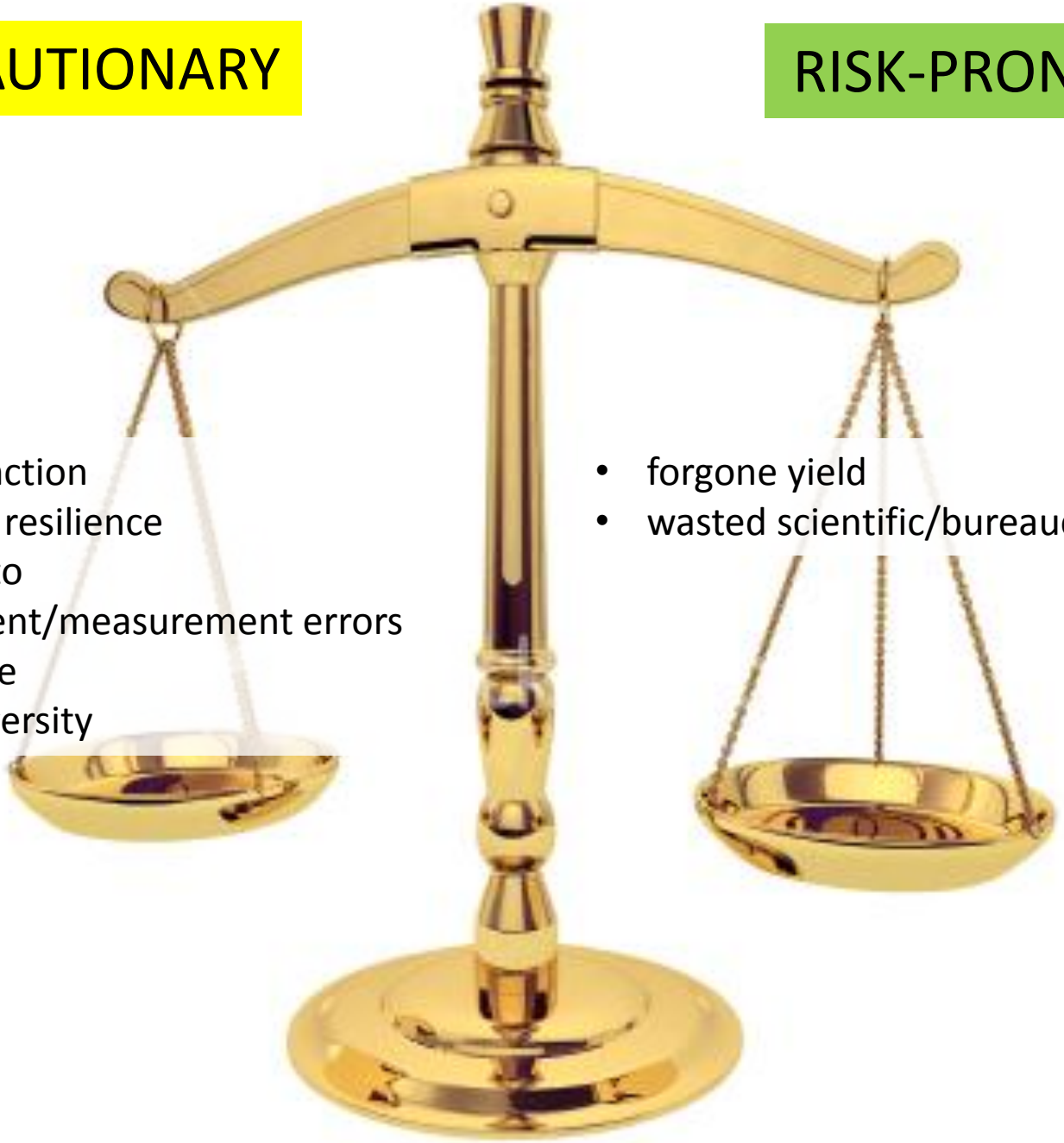


What does this mean for management?

- Play to the mean, using proxies for F_{MSY} and B_{MSY}
  - Haltuch and Punt, 2009; Clark, 1993.
- Use proxies for F_{MSY} and B_{MSY} and change expectations for recruitment based on regime
  - A'mar et al. 2011; Szuwalski and Punt, 2012
- Ignore target biomasses, use target fishing mortalities
  - Walters and Parma, 1996; ICES, NE US
- Synthesis:
  - Proxies for F based on life history, risk analysis for target biomass
  - Francis, 1992

PRECAUTIONARY

RISK-PRONE



- trophic function
- ecosystem resilience
- resilience to management/measurement errors
- higher cpue
- genetic diversity

- forgone yield
- wasted scientific/bureaucratic effort